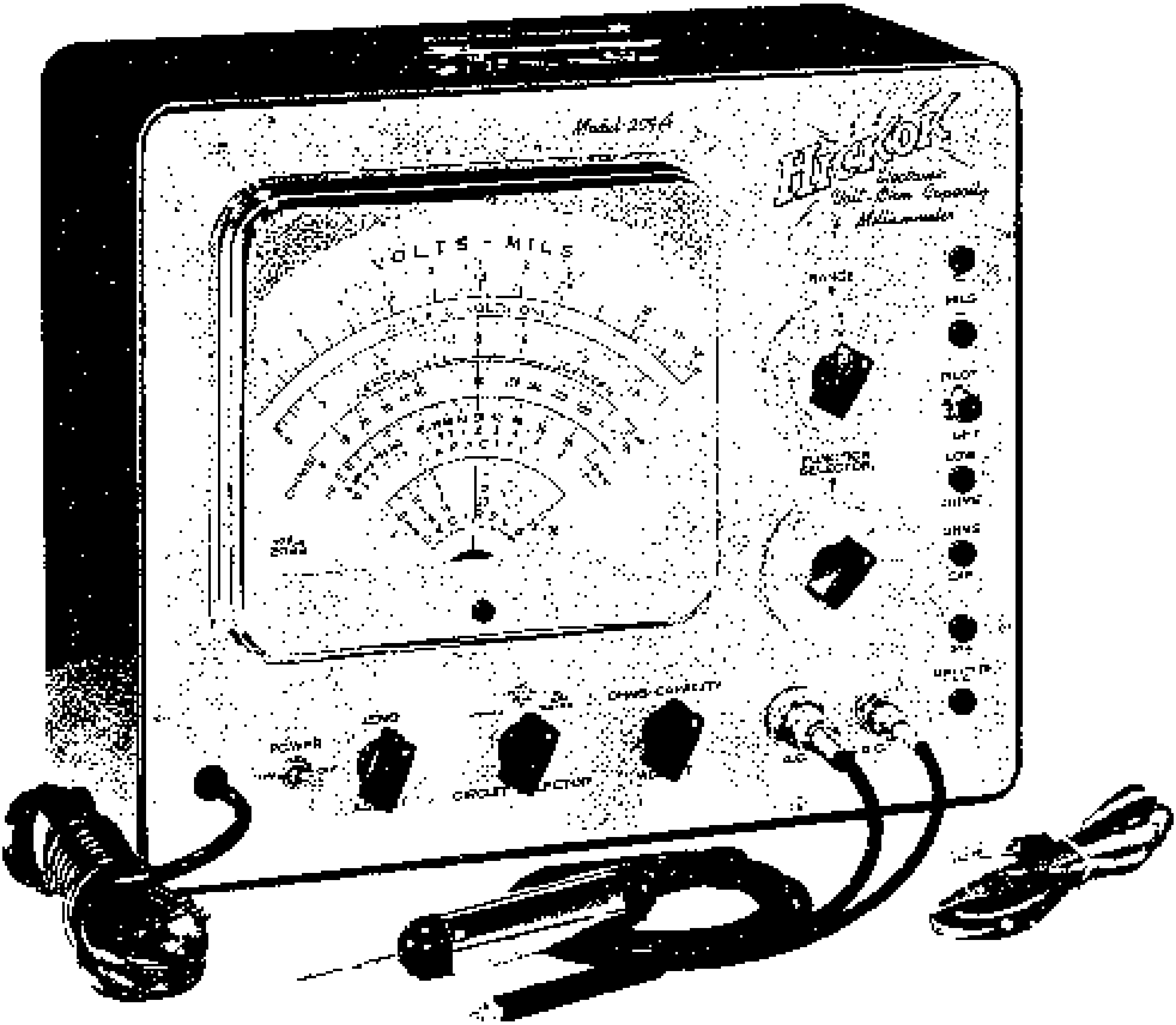
OPERATING INSTRUCTIONS

VACUUM TUBE VOLT-OHM-CAPACITY-MILLIAMMETER

MODEL 209A

CHOICE OF THE EXPERTS FOR SPEED, ACCURACY and DEPENDABILITY...



HICKOK ELECTRONIC VOLT OHM-CAPACITY-MILLIAMMETER

MODEL 209A

FIGURE 11

TECHNICAL DATA SHEET

EQUIPMENT SUPPLIED

(ONE COMPLETE UNIT)

Quan.	Name	Type	Stock No.	Dimensions	Weight
1	Vacuum Tube Volt-Ohm-Capacity Milliammeter	209A	902-173	16" x 13" x 7"	
1	Instruction Book		2490-201		
1	Test Lead - Red		12450-93	48"	
1	Test Lead - Black		12450-99	48"	
1	A.C. Probe Assembly		16970-15	48"	
1	D.C. Cable Assembly		3030-46	48"	

TECHNICAL CHARACTERISTICS

1. Power Supply Required: 105 - 125 V, 50 - 70 Cycles, a.c.

2. Power Consumption: 20 watts at 115 V.

3. Scales:

a.	VOLTS MILS:	0 - 3, 0 - 12
b.	0-3 VOLTS A.C. ONLY:	0 - 3
c.	OHMS:	0 - 10,000 - Inf.
d.	CAPACITY:	MMF - 0 - 1000 - Inf. MF - 0 - 10 - Inf.
e.	VOLTS:	Zero Center D.C.

4. RANGES:

a.	VOLTS, A.C., RMS	0 - 3, 12, 30, 120, 300, 1200
b.	VOLTS, A.C., Peak-to-Peak:	0 - 3, 12, 30, 120, 300
c.	VOLTS, D.C.:	0 - 3, 12, 30, 120, 300, 1200
d.	MILS (d.c.):	0 - 3, 12, 30, 120, 300, 1200
e.	CAP:	0 - 10,000 mmf, in 2 ranges 0 - 1,000 mf, in 5 ranges 50 mh - 100 henries (use conversion chart)
f.	OHMS:	1 ohm to 10,000 megohms, in 8 ranges

5. Frequency: A.C. to over 100 megacycles may be measured.

6. Meter:

   a. Type: S22-46F
   b. Sensitivity: 500 Microamperes

7. Tube Complement:

	Tube	Stock No.	Function
V1	6AL5	20875-51	A.C. input rectifier
V2	6X5GT	20875-22	Capacity voltage rectifier
V3	6SJ7	20875-17	Cathode follower
V4	6SN7GT	20875-19	Vacuum tube voltmeter
V5	6X5GT	20875-22	A.C. power rectifier

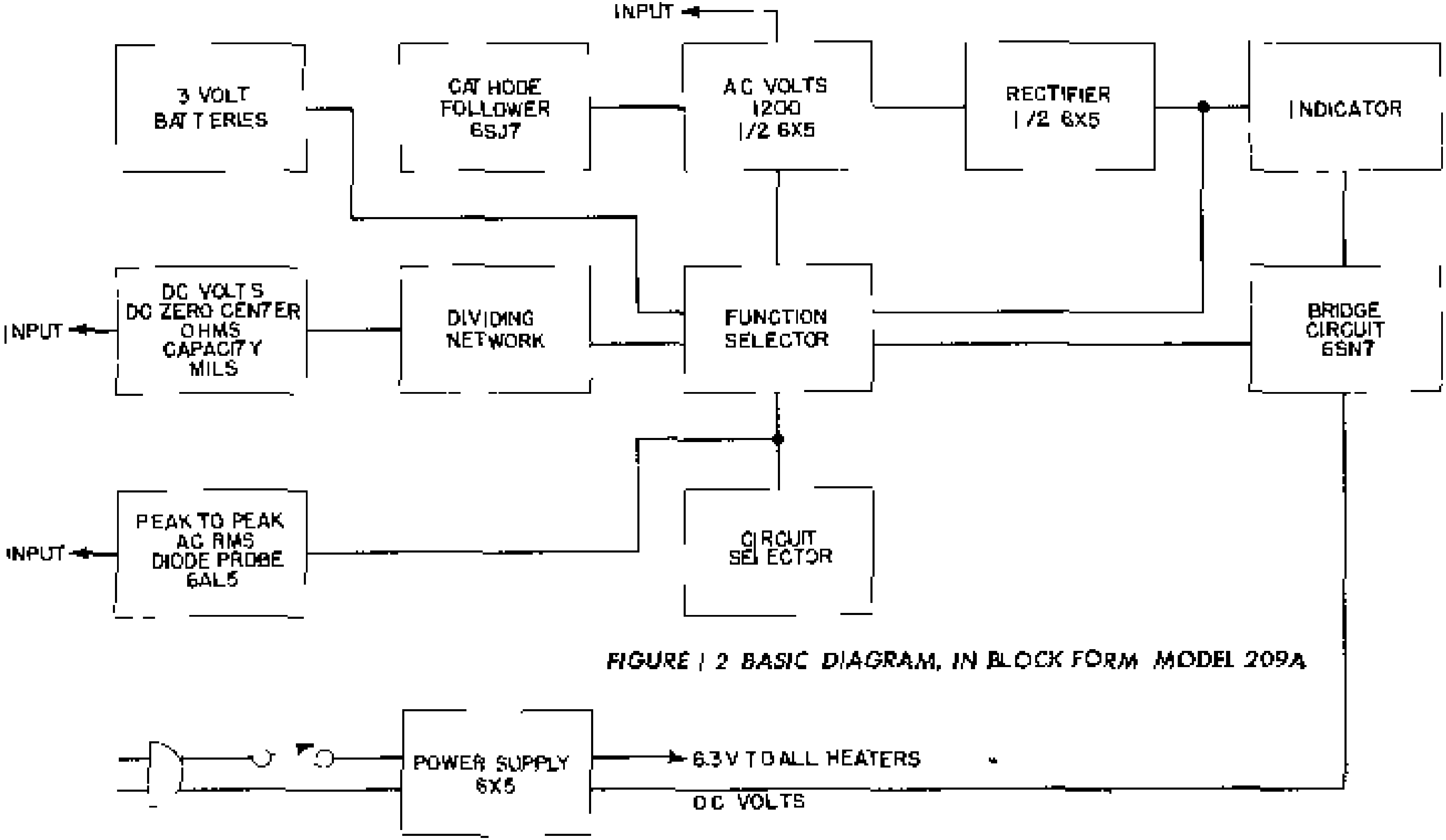


FIGURE 1 2 BASIC DIAGRAM, IN BLOCK FORM MODEL 209A

SECTION 1 - DESCRIPTION

1.1 PURPOSE

The Hickok Vacuum Tube Volt-Ohm-Capacity-Milliammeter, Model 209A, shown in Figure 1.1, is a practical universal test instrument which may be used in making measurements in the study and repair of radio, electronic and television circuits. It is a versatile instrument, as the measurements of wide ranges of d.c. currents, a.c. and d.c. voltages, resistances, capacitances and inductances may all be made by one unit. The very large meter scales provide ease of reading, even from some distance away. Built under Hickok high standards of workmanship, it is an accurate and durable test instrument.

1.2 DESCRIPTION

a. Physical

The instrument is enclosed in a metal case with a handle at the top and with feet on two sides, so that the instrument may be used in either a horizontal or vertical position. The chassis is mounted on the front panel and is accessible by removing the eight screws holding the panel to the case and then removing the panel. The large meter is accurately calibrated with the scales clearly marked. A mechanical adjustment of the zero setting is provided on the front of the meter. A diode probe and shielded cable is supplied for a.c. voltage measurements, and is attached to the unit by means of a four-prong connector plug. Two additional leads are furnished for all the other measurements. All switches, jacks and controls are clearly marked on the front panel.

b. Components

The following leads, as shown in Figure 1.3, are furnished with the Model 209A:

(1) An a.c. probe and shielded cable assembly is furnished for making a.c. voltage measurements to 300 volts. This cable is 48" long with a four-prong male plug on one end and the special a.c. probe on the other. The circuit of this probe is shown on the schematic diagram, Figure 7.1.

(2) A 48" shielded test lead with an isolating resistor incorporated in the probe is supplied for making all d.c. measurements. This lead has a test prod on one end and a microphone type of connector on the other.

(3) Two unshielded test leads, 48" long, are supplied for making all resistance, capacity, inductance and current measurements. One of these leads, black, with a pin plug on one end and an alligator clip on the other, is used as a ground lead for all measurements. The other lead is red, and is terminated with a pin plug and test prod.

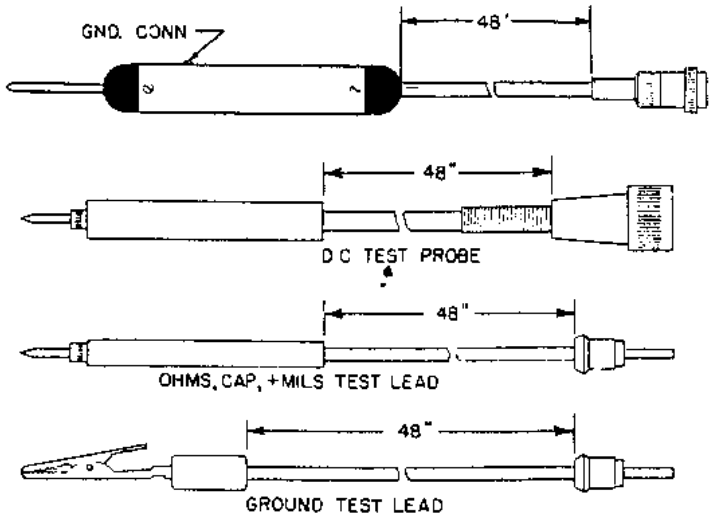


FIGURE 1.3 TEST LEADS

c. Functional

The Model 209A is designed to perform the following electrical functions:

(1) To measure a wide range of d.c. currents, a.c. voltages in terms of RMS, or peak-to-peak value, d.c. voltages, resistances, capacitanoes and inductances.

(2) To measure a.c. voltages accurately over a very wide range of frequencies.

(3) To nave a very light loading effect on the circuit under test, thereby insuring greater accuracy.

(4) To have a meter circuit design which will eliminate the possibility of damage to the meter from overload. (Milliammeter circuit excepted.)

d. Electrical

(1) A 105 - 125 volt, 50-70 cycle a.c. external power source is needed for the operation of the power supply system which has been incorporated in the unit to supply all d.c. plate voltages and a.c. heater voltages. The power supply circuit is of the conventional type, consisting of a transformer, rectifier and filter. D.C. voltage needed for ohmmeter measurements is supplied by two dry cells, in series, also incorporated in the instrument.

(2) Three separate voltage divider networks are used in the ouput circuit; one for current measurements, one for resistance and

capacitance measurements, and one for a.c. and d.c. voltage measurements. The FUNCTION SELECTOR switch, in conjunction with the CIRCUIT SELECTOR, determines which network is to be used, and the RANGE switch determines the position within the network. A switching arrangement has been incorporated so that voltages, either positive or negative with respect to ground, may be measured by merely operating the switch to the correct d.c. position, rather than reversing the position of the leads themselves. A d.c. volt zero center position is also incorporated for measuring potentials for a null balance.

(3) In measuring d.c. currents, the unknown is applied directly to the meter with its parallel shunt network. In d.c. voltage measurements, the input is placed across the proper voltage dividing network, from which the correct portion for a given range is applied to the grid circuit of a vacuum tube bridge. In a.c. voltage measurements, the input is rectified in the diode probe before being placed across the divider network. In a.c. peak-to-peak the input is rectified by a voltage doubler circuit before being applied to the divider network. In resistance measurements, the unknown is placed in series with an internal source of d.c. voltage and a portion of the divider network depending on the range used. The voltage drop across the unknown is applied to the grid of the bridge circuit. In capacitance and inductance measurements, the unknown is placed in series with an internal source of a.c. voltage and a portion of the divider network. The a.c. voltage drop across the unknown is applied to a *cathode follower*, the output of which is rectified by electronic means, and then impressed on the grid of the bridge vacuum tube.

SECTION 2 - PRELIMINARY CHECKS FOR OPERATION

A. C. PROBE MUST BE CONNECTED

2.1 GENERAL

a. Before attempting to make any specific measurements with the Model 209A, the following steps should be taken to determine whether or not the instrument is functioning properly in all respects.

(1) Make visual inspection of the unit to see that it has not been damaged in shipment. Be sure that all test leads are with the unit. Refer to Figure 1.3 - Test Leads. Observe if the indicator is at zero. To reset to zero, turn mechanical adjust on the indicator with a screwdriver. Plug unit into the a.c. line and operate the power switch to ON. The pilot light should come on.

(2) After one minute warm-up, turn FUNCTION SELECTOR to A.C. VOLTS and the CIRCUIT SELECTOR to NORMAL. Rotate the RANGE SELECTOR to 3 VOLTS. Adjust Zero Adjust Control until the indicator comes to zero.

(3) Turn FUNCTION SELECTOR to + D. C. and — D.C. respectively. It should be possible to adjust the indicator to zero by means of the ZERO ADJ. control on both of these positions.

(4) Turn FUNCTION SELECTOR to OHMS and short out the ohms test leads. It should be possible to adjust the indicator to zero ohms by means of the ZERO ADJ. control. Then short the test leads and remove the red test lead from the OHMS-CAP jack. By means of the OHMS-CAP ADJ. control it should be possible to adjust the indicator to infinity (INF.).

(5) Turn FUNCTION SELECTOR to CAP. and repeat the procedure outlined in paragraph (4). It should be possible to adjust the indicator to zero capacity except on the most sensitive (X1 MMF) range where the indicator will probably drop down to approximately 30 or 40 mmf which is the internal capacity of the instrument with the red lead disconnected from the OHMS-CAP. jack.

(6) Turn FUNCTION SELECTOR to MILS. The indicator should go to zero.

(7) Rotate FUNCTION SELECTOR back to A.C. VOLTS. Turn CIRCUIT SELECTOR to PEAK-TO-PEAK and adjust to zero with Zero Adjust Control.

(8) Rotate FUNCTION SELECTOR to + D.C. Rotate CIRCUIT SELECTOR switch to D.C. zero center. It should be possible, by means of the ZERO ADJ. control, to set the indicator to center scale zero.

b. If, in any event, any of the above checks are not normal, the factory should be contacted, giving the nature of the trouble. Instructions will then be given for either correcting the trouble or returning the equipment. Address all service inquiries to the Hickok Electrical Instrument Company, 10514 Dupont Avenue, Cleveland 8, Ohio.

SECTION 3 - THEORY

3.1 GENERAL

A thorough understanding of the theory behind the operation of any instrument will enable the user to obtain greater utility and satisfaction from the instrument. For this reason the following brief explanation of the circuit of the Hickok Vacuum Tube Volt-Ohm-Capacity-Milliammeter Model 209A is given. As the principles of operation rather than detailed explanation of the operation is intended, the full schematic, shown in Figure 7.1, is greatly simplified. The power supply incorporated in the unit is of the usual type employing a transformer, full-wave rectifier and an input capacitator, therefore no explanation of it is given. The milliammeter circuit, as shown in Figure 3.1,

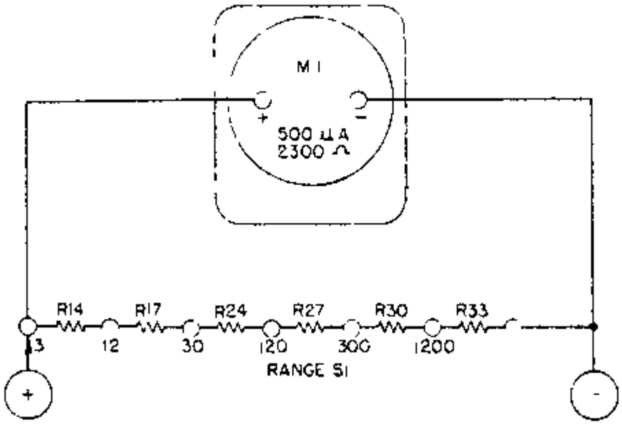


FIGURE 3.1 MILLIAMMETER CIRCUIT

also needs no detailed explanation, as it is simply a meter shunted by a resistance network whose value is determined by the range of the current to be measured.

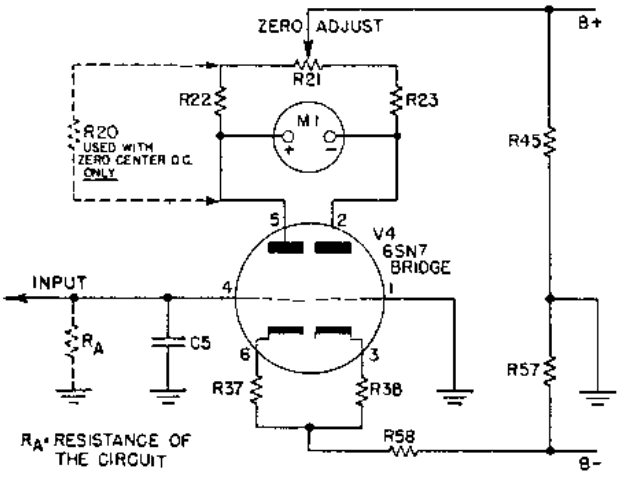


FIGURE 3.2 BASIC BRIDGE CIRCUIT

3.2 BRIDGE CIRCUIT

a. The bridge circuit is common to all measuring circuits except the milliammeter section. Specific application of the bridge is given in the explanation of the type of measurement to be performed, i.e., resistance, capacitance or voltage.

b. The basic circuit of the bridge is similar to the common Wheatstone bridge in operation. Voltage is applied across the bridge; B+ at R45 and B- through resistor R57, at the junction of R22 and R23. R21 acts as a zero adjustment and is adjusted so that with no voltage input to either grid of the tube, the meter reads zero, indicating balance between the two triodes of the twin triode used as the bridge tube. When making all measurements, except capacity measurements, the grid of one triode remains at ground potential, and the grid of the other triode changes to a potential determined basically by the unknown being measured. Changing the potential of only one of the grids will unbalance the bridge and cause a deflection of the meter in direct proportion to the change in grid potential, as the plate current changes with grid potential. The meter has a calibrated scale which interprets this deflection in terms of volts, ohms, or units of capacity, so that in conjunction with the RANGE SELECTOR, the unknown can be evaluated directly from the scale reading. This is basically the action of the bridge and meter. The type of measurement to be made will determine both the input grid to be used and the method of obtaining the input voltage.

3.3 A.C. VOLTMETER

a. Normal Position - With reference to Figure 3.3 and the switch in the normal position, the a.c. voltage to be measured is rectified by one-half of the 6AL5 twin diode, and the resultant d.c. voltage is applied to the divider network. Part of this voltage, as determined by the position of the Range Control, is fed to the input grid of one of the triodes of the bridge tube causing the bridge circuit to function. In this normal position the instrument is calibrated to read in terms of RMS voltages of a sine wave.

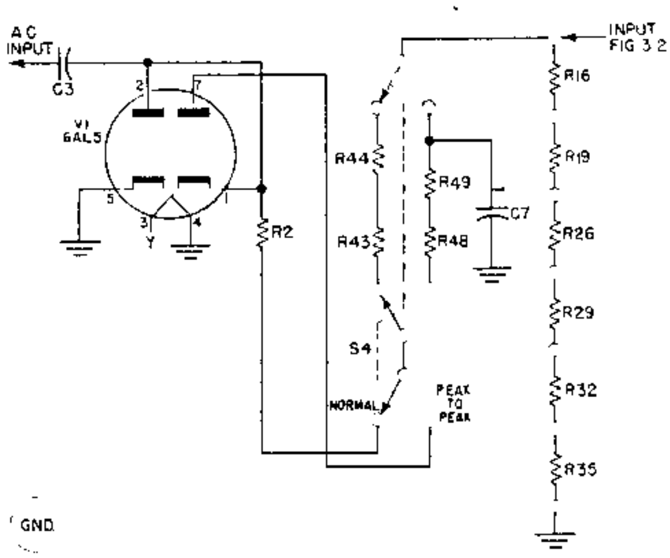


FIGURE 3.3 A.C. VOLTMETER CIRCUIT

b. Peak-to-Peak Position - When the switch is operated to the peak-to-peak position, and a voltage to be measured is applied to the input, the action of the twin diode and the input and output capacitor will rectify this incoming a.c. voltage and apply it to the divider network. Part of this resultant d.c. voltage will be applied to the grid of the bridge tube, depending upon where the Range Control is set. In this position the instrument is calibrated in peak-to-peak and is useful in the measurement of the overall portion of a.c. voltages.

c. Negative contact potential is developed across the rectifier tube before any input voltage is applied, due to the normal emission of electrons by the cathode. In either position of the switch (normal or peak-to-peak), this negative potential is applied across the input voltage divider network and would cause the meter to deflect. To compensate for this undesirable deflection, a positive voltage from the B+ supply equal to the contact potential is fed to the voltage divider network through a 90-megohm resistor. The A.C. Voltmeter, 1200 volts, with reference to Figure 3.3 (a), consists of one-half of a 6 x 5 Diode Rectifier. This rectifier voltage is applied to R35 of the voltage divider network and impressed on a grid of the bridge tube circuit.

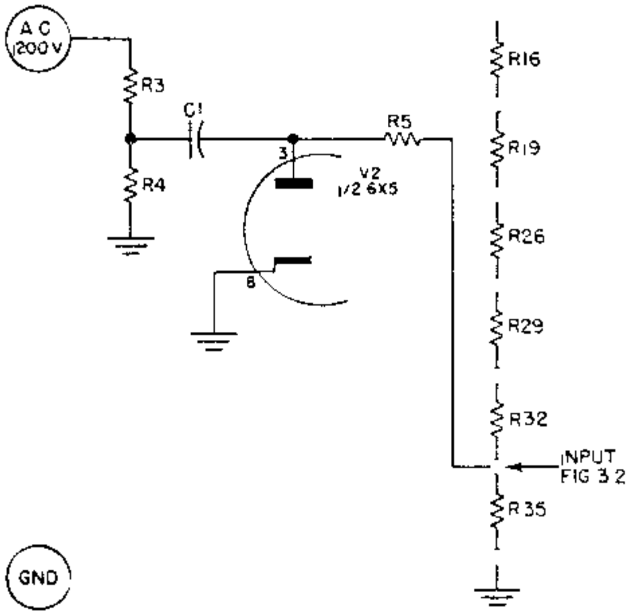


FIGURE 3.3a A.C. VOLTMETER - 1200 VOLTS

3.4 D.C. VOLTMETER

a. The d.c. input voltage, applied to the D.C. and GND connections of the instrument, is applied through a one-megohm resistor in the probe directly to the voltage divider network, as shown. A part of this voltage, as determined by the position of the Range Control, is fed to the input grid of one of the triodes of the bridge tube, causing the bridge circuit to function. Deflection of the meter pointer in the wrong direction indicates that the polarity of the voltage being measured is reversed with respect to the polarity of the meter and bridge circuit. A switching arrangement has been incorporated in the instrument, however, which switches the input grids of the bridge tube to permit measurements of either polarity.

b. Zero Center Position - With reference to Figure 3.4, the Circuit Selector Control is operated to the D.C. Zero Center position and will partially short R17, tending to draw more current and unbalance the bridge approximately to center scale. This is useful for alignment of discriminator stages of F-M and TV receivers.

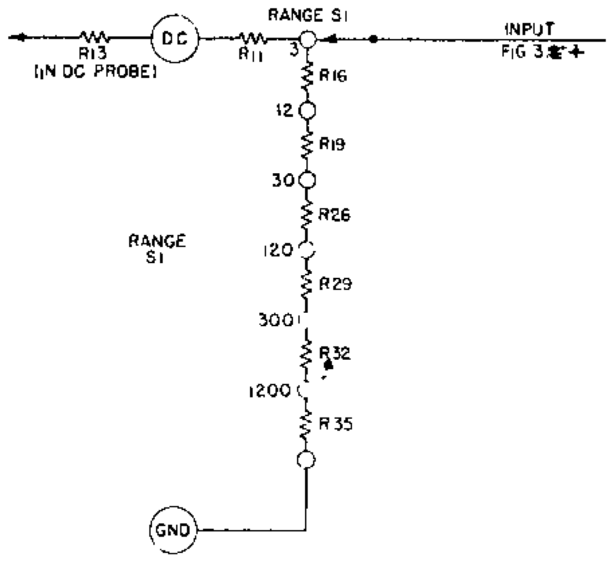


FIGURE 3.4 D.C. VOLTMETER

3.5 OHMMETER

a. When an unknown resistance is connected across OHMS-CAP. and GND terminals, it is placed in series with a portion of the input voltage divider network, as determined by the Range Control and the dry cells incorporated in the instrument.

b. The voltage applied to the input grid of the bridge tube is the voltage across the unknown resistance caused by the battery current flow. The meter deflection can be calibrated in the terms of resistance.

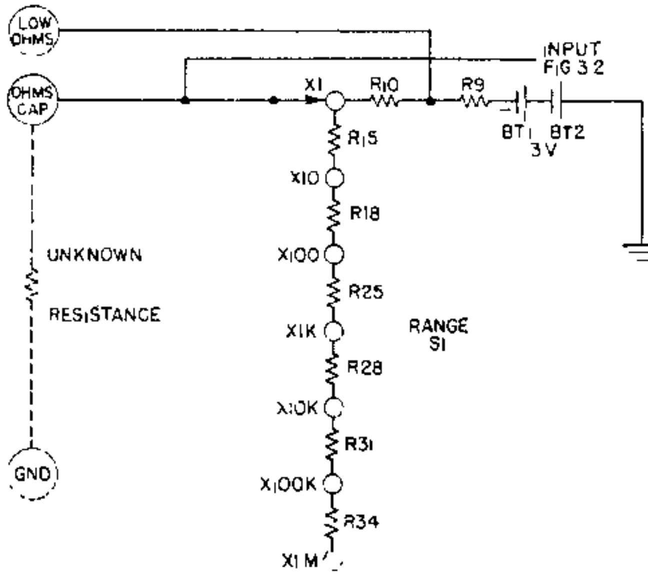


FIGURE 3.5 OHMMETER CIRCUIT

3.6 CAPACITY AND INDUCTANCE MEASUREMENTS

a. Capacity

The theory of the capacity measurement is similar to that of the ohmmeter, with the impedance of the unknown capacitor replacing the unknown resistance. However, as an a.c. voltage is needed to measure the capacitance, and as only d.c. can be applied to the input grid of the bridge tube, some means must be used to rectify the a.c. The a.c. voltage tapped off the voltage divider network is fed to the grid of a cathode follower which is used in the circuit as an impedance matching device. The cathode output is fed to the rectifier circuit, which consists of V1, a condenser C2, and a resistance R3. The output of the rectifier is fed to the input grid of the bridge tube.

b. Inductance

The theory of the inductance measurements is similar to that of a capacitance measurement with the impedance of the inductance coil replacing the impedance of the capacitor. As the capacity scale is used in making measurements, a chart is given in Figure 5.1 which relates capacity readings to impedances. This impedance, in its effect in the circuit, may be due to either an inductance or a capacitor. With the aid of a simple formula the inductance can be determined.

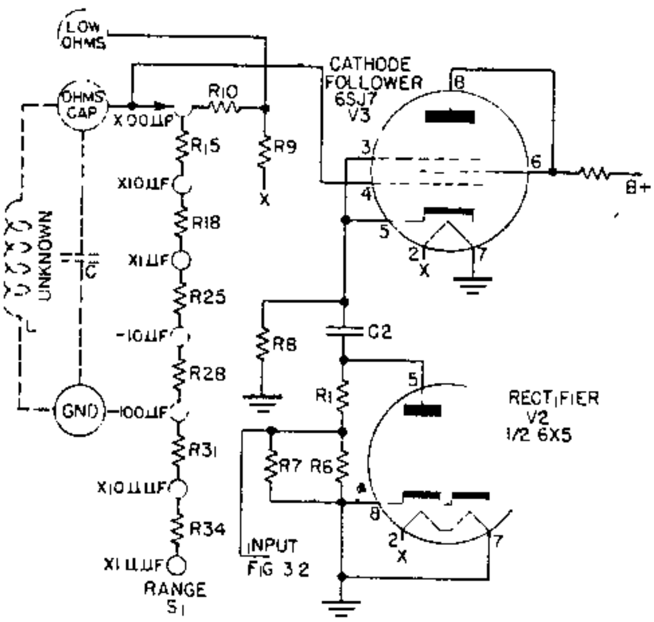


FIGURE 3.6 CAPACITY AND INDUCTANCE MEASUREMENTS

SECTION 4 - OPERATION

CAUTION

THE HIGH VOLTAGES WHICH CAN BE MEASURED WITH THIS EQUIPMENT MAY BE DANGEROUS TO LIFE. EXTREME CARE SHOULD BE TAKEN TO AVOID BODILY CONTACT WITH EXPOSED HIGH VOLTAGES.

4.1 GENERAL

a. To avoid error in resistance, capacitance and inductance measurements, be sure that the unknown to be measured is isolated from other circuits. In capacity and inductance measurements, it is advisable to remove the unknown from the circuit entirely. In resistance measurements, it is sufficient to free only one terminal of the resistor.

b. Be sure that the instrument is being operated from the correct external power source. It is necessary to allow a two or three-minute warm-up period so that stable operation is assured. If the instrument is to be used intermittently over a period of time, it is advisable to keep it turned on to avoid delay.

4.2 A.C. VOLTAGE MEASUREMENTS

DO NOT ATTEMPT TO MEASURE A.C. POTENTIALS OVER 300 VOLTS WHEN USING PROBE.

a. Normal Position

(1) Operate the POWER switch to ON.

(2) Connect the a.c. probe to the unit by means of the four-prong connector plug.

(3) Connect the black unshielded test lead to the GND jack. If voltages are being measured at frequencies over 100 megacycles, a braided ground connection should be made from the diode probe to the unit being tested. This lead should be as short as possible.

(4) Turn the FUNCTION SELECTOR switch to VOLTS A.C.

(5) Turn CIRCUIT SELECTOR to "Normal".

(6) Turn the RANGE switch to the range which will cover the voltages to be measured. If this is unknown, choose the highest range.

(7) Check the meter for zero setting. Adjust to zero with the Zero Adjust control. In setting the meter to zero do not touch the prod on the a.c. probe, as the stray pick-up will deflect the meter.

(8) Connect the a.c. probe and the black test lead to the voltage to be measured.

(9) Read the numerical value from the scale directly and apply the multiplying factor for the position of the RANGE switch.

b. Peak-to-Peak

DO NOT ATTEMPT TO MEASURE OVER 500 VOLTS PEAK-TO-PEAK.

(1) Procedure for a.c. peak-to-peak measurements is identical to that outlined in paragrath 4.2a, with the exception of Step 5 which, in this case, should be changed to "Peak-to-Peak".

4.3 D.C. VOLTAGE MEASUREMENTS

a. Normal

(1) Turn the FUNCTION SELECTOR switch to VOLTS + D.C.

(2) Turn the CIRCUIT SELECTOR to "Normal".

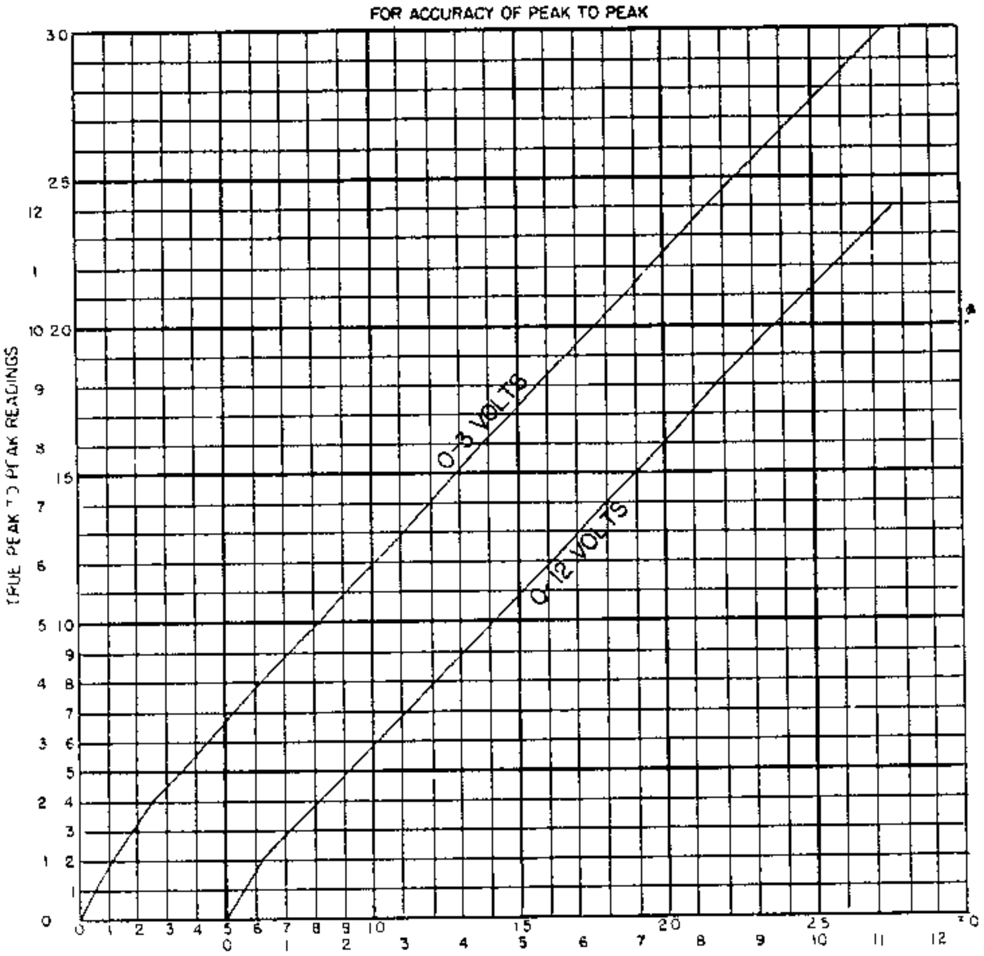


FIGURE 4.1 PEAK-TO-PEAK CHART

c. 1200 Volts A.C.

(1) Connect red test lead to 1200 Volt jack.

(2) Connect black test lead to ground jack.

(3) Turn FUNCTION SELECTOR switch to VOLTS A.C.

(4) Turn CIRCUIT SELECTOR switch to NORMAL.

(5) Turn RANGE switch to 1200 VOLTS.

(6) Check meter for zero setting and adjust to zero with Zero Adjust Control.

(7) Connect red and black leads to voltage to be measured.

(8) Read voltage directly from scale.

(3) Turn the RANGE SELECTOR to the range which will cover the voltages to be measured. If an approximate range is unknown, choose the highest range.

(4) Check the meter for zero setting at the range at which the measurement is to be made. Adjust to zero with the Zero Adjust Control.

(5) Connect the unknown, using the black ground lead furnished and the shielded cable with the microphone connector.

(6) If the meter reads in the wrong direction, operate the SELECTOR switch to VOLTS - D.C.

(7) Read the numerical value from the scale directly and apply the multiplying factor for the position of the RANGE control.

b. Zero Center

(1) Turn FUNCTION SELECTOR switch to + D.C. VOLTS.

(2) Turn CIRCUIT SELECTOR switch to "zero center" position.

(3) Turn RANGE switch to range which will cover voltage to be measured. If an approximate range is unknown, choose the highest range.

(4) Check meter for zero setting at the range at which the measurement is to be made.

(5) Adjust to center zero with Zero Adjust Control.

(6) Connect to unknown voltage using black ground lead furnished and shielded cable with microphone connector.

4.4 CURRENT MEASUREMENTS

a. To avoid possible injury to the meter, always make measurements using the highest range first.

b. To avoid error due to an inaccurate initial setting of the meter, check the zero reading of the meter before making any measurements. Adjust the zero setting mechanically by means of the screwdriver adjustment in the front of the meter, if necessary.

c. Turn the SELECTOR switch to MILS.

d. Turn the RANGE SELECTOR to the range which will cover the currents to be measured. If an approximate range is unknown, choose the highest range.

e. Connect the unknown, using the black ground lead for - MILS and the red lead for + MILS.

f. Read the numerical value from the scale directly and apply the multiplying factor for the position of the RANGE control.

4.5 RESISTANCE MEASUREMENTS

a. Turn the FUNCTION SELECTOR switch to OHMS.

b. Turn CIRCUIT SELECTOR to "Normal".

c. Turn the RANGE switch to the range which will cover the resistance to be measured. If it is desired to use the LOW OHMS scale, turn the RANGE switch to the X1 position.

d. Connect the red and black leads to the OHMS CAP and GND jacks respectively. When using the LOW OHMS scale, connect the leads to the LOW OHMS and GND jacks. Adjust the meter to zero with the ZERO ADJUST control, while shorting the test leads together. Open the leads and adjust the meter to full scale with the OHMS-CAPACITY ADJUST control.

e. Connect the unknown resistance between the test leads, making sure that it is isolated from any other circuit components which might introduce error.

f. Read the numerical value from the scale directly and apply the multiplying factor for the position of the RANGE switch. Note: When measuring LOW OHMS, read the numerical value from the scale and divide the reading by 10.

CAUTION

DO NOT SHORT THE LEAD FROM THE LOW OHMS JACK TO GND UNLESS THE SELECTOR SWITCH IS ON THE OHMS POSITION, AS THERE IS A POSSIBILITY OF BURNING OUT RESISTOR R5.

4.6 CAPACITANCE MEASUREMENTS

a. Turn the FUNCTION SELECTOR switch to CAP.

b. Turn CIRCUIT SELECTOR switch to NORMAL.

c. Turn RANGE switch to the range which will cover the capacity to be measured.

d. Connect the red and black leads furnished to OHMS CAP and GND respectively, and check the zero setting by shorting the leads together. Adjust to zero with the Zero Adjust Control. Open the leads and check for full-scale deflection. Adjust to full scale with the OHMS-CAPACITY ADJUST control.

e. With the exception noted below, connect to the capacitor to be measured, using the red and black leads furnished. The capacitor should be removed from its associated circuits in making this measurement.

IMPORTANT

(1) Since the capacity measuring circuit is exceedingly sensitive on the two lowest capacity ranges (X1 and X10 MMF), the test leads will pick up any stray a.c. voltage fields near the leads. This will generally cause the meter to read off-scale on the right, which results in erratic readings. It is therefore advisable to connect the capacitor under test directly to the OHMS-CAP. and GND pin jacks when using either of these two ranges.

(2) In the event of any apparent instability other than referenced in Paragraph (1) above, reverse the line cord plug.

NOTE

Since the instrument has an appreciable internal capacity of approximately 20-30 mmf, the meter, when the Range Switch is turned to the X1 MMF range, will read this capacity. Be sure to adjust the indicator to full scale with the OHMS-CAPACITY ADJUST control when on some range other than the X10 or X1 MMF, even though it is known that one of these ranges will be used in actual measurement. Do not re-adjust this control when changing to these ranges, but note the reading on the indicator before the unknown capacity is connected. Then subtract this reading from the reading with the capacitor connected to obtain the true capacitance of the unknown.

f. Multiply the numerical value indicated on the scale by the multiplying factor indicated by the RANGE control. In cases where it is necessary to use the X1 and X10 MMF ranges, the true value of the unknown will be the difference between the meter reading with and without the capacitor connected.

g. CAPACITY MEASUREMENTS WHEN USED ON OTHER THAN 60 CYCLE SUPPLY - A simple conversion factor may be used to convert capacity readings for other than 60 cycle operation. This formula is as follows:

$$CA = \frac{Cm\ 60}{f}$$

Where CA = Actual Capacity

CM = Measured Capacity

f = line supply frequency

In the case of 50 cycles, the above formula could be reduced to CA = 1.2 Cm.

4.7 INDUCTANCE MEASUREMENTS

a. Turn the FUNCTION SELECTOR switch to CAP.

b. Turn CIRCUIT SELECTOR switch to NORMAL.

c. Turn the RANGE switch to X100 MFD.

d. Insert the red and black test leads into the jacks marked OHMS CAP and GND and check the zero setting by shorting the leads together. Adjust the meter to zero with the ZERO ADJUST control.

e. Open the leads and adjust the meter to full scale with the OHMS-CAPACITY ADJUST control.

f. Insert the inductance to be measured between the test leads. If the meter reads zero on the X100 MFD scale, the inductance is too small to be read on the Model 209A.

g. Rotate the RANGE switch clockwise until a suitable reading can be obtained from the meter. The numerical value of capacity is noted and applied in the formula:

$$L = \frac{7.04}{C} \text{ henries}$$

where C is in MFD. NOTE: This formula is accurate only if the ohmic resistance of the inductance is negligible with respect to the inductive reactance at 60 cycles. The accuracy of calculation is greater than 1% if the product of the ohmic resistance and the capacity reading in MFD is less than 100 ($RC<100$).

h. If the ohmic resistance is appreciable, proceed to calculate the inductance as follows:

(1) Read the numerical value of the capacity directly from the scale. Find the associated impedance on the graph given in Figure 5.1. This value is ZL in the formula below.

(2) Note the RANGE SELECTOR, whether it is on X1 - X10 - X100, etc. ohms. This value is in the formula below.

(3) Determine the resistance of the inductance by means of an ohmmeter. This value is RL in the same formula.

(4) Knowing RL and whether the selector switch was on X1 - X10 - X100 etc., also knowing RL determines the inductive reactance XL from the formula below.

Example: It is desired to find the inductance of a coil whose resistance, when measured by an ohmmeter is 100 ohms. The CAP reading obtained from the Model 209A was 8.8 MFD on X10 MF Range, which also was the X10 ohms range.

$$XL = ZL\sqrt{1-\left(\frac{RL}{ZL}\right)^2 + \frac{.02\ RL}{X1 - X10 - X100}} \text{ etc.}$$

RC = 8.8 x 100 = 880

RC is greater than 100

Therefore, the error due to the resistance is greater than 1%. Referring to the graph in Figure 5.1, we find that the impedance for a capacity reading of 8.8 MFD is 300 ohms. Substituting in the formula:

$$XL=300\sqrt{1-\left(\frac{100}{300}\right)^2 + \frac{.02 \times 10\not{0}}{1\not{0}}} =$$

$$300\sqrt{1 - .111 + .2} = 300\sqrt{1.1} =$$

XL=300 x 1.05 = 315 ohms

$$L=\frac{XL}{377} = \frac{315}{377}\quad .835 \text{ Henries}$$

4.8 DECIBEL MEASUREMENTS

a. The decibel scale can be used to determine the power level based on 0 DB = 6 mw. The operation of the Model 209A is the same as that under paragraph 4.2, a.c. voltage measurements. The ranges used for the various scales are clearly marked on the meter dial with the minus values indicated in red and the plus values in black.

b. The following formula can be used to convert the DB reading to watts, provided the reading is taken across a 500 ohm load.

$$\text{FORMULA: } DB = 20 \log. 10 \frac{P}{.006}$$

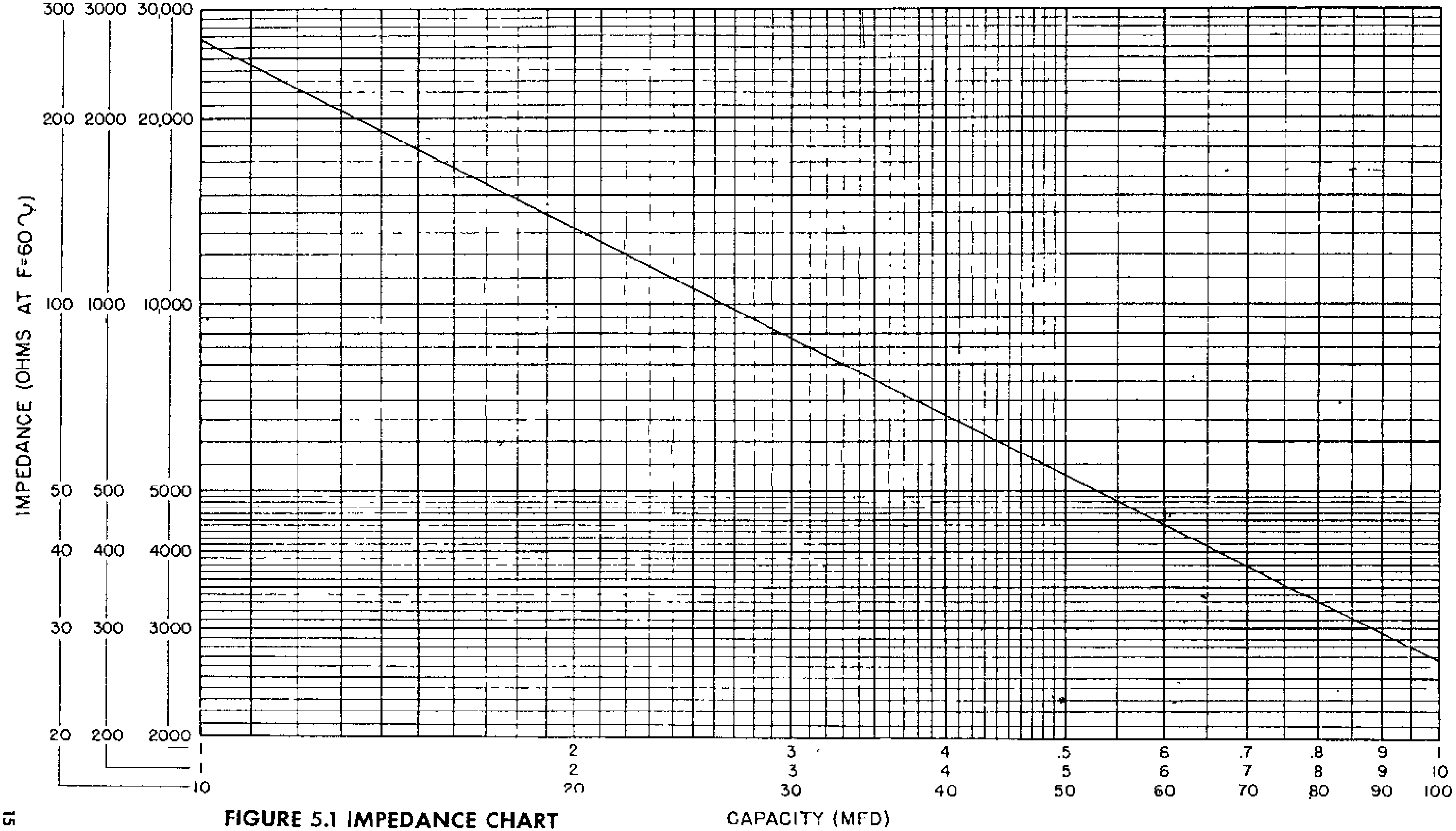


FIGURE 5.1 IMPEDANCE CHART

SECTION 5 - APPLICATION

5.1 GENERAL

The following applications are very general in nature, as it is always advisable to consult the instructions pertinent to the instrument under test to obtain the actual procedures in making a test. The Hickok Electronic Volt-Ohm-Capacity-Milliammeter, Model 209A, may, of course, be used in making all *measurements common to an instrument of* its type. These applications given here will give more specialized use of which the user may not be aware.

5.2 D.C. VOLTMETER

a. *Zero Center or Zero Left*

The input impedance in the vacuum tube voltmeter is constant at approximately 12 megohms for all ranges. As the result of this high input impedance, it can, in general, be used to measure d.c. voltages in any electrical circuit without appreciably loading down the d.c. circuit, and consequently, the voltage as indicated will be essentially the voltage which would be found under normal operating conditions. In the conventional low impedance type of voltmeter the loading caused by the meter is often sufficiently great to cause extreme error when measurements are made in high impedance circuits.

b. R-F - I-F Circuits

As a result of the incorporation of an isolating resistor of one megohm in the d.c. probe, this voltmeter can also be used to measure voltages in oscillating or r-f circuits without loading these circuits from a capacitive or resistive standpoint. This feature makes it possible to measure avc voltages at such places as the control grids of r-f and i-f stages without disturbing the *normal operation of those circuits.*

c. Oscillation Check

Determination of the condition of oscillation or *non-oscillation*, of the oscillator sections in receivers is another application of the voltmeter. An immediate check is obtained on the oscillator section by connecting the voltmeter, so as to measure the voltage at the grid of the oscillator tube and *tuning from one end of the band to the other.* Note the grid voltage throughout the entire range. Normally a negative voltage of from 5 to 30 volts will be found at the grid of the oscillator tube when the oscillator section is operating properly. Dead spots on *one or more of the tuning ranges* may be located by this test.

d. Discriminator Circuit Alignment

Service instructions for the alignment of frequency modulated receivers often call for the insertion of a zero center microammeter in the discriminator circuit. Misalignment is indicated by any reading, either positive or negative, on the meter and alignment is indicated by a zero reading. The d.c. voltmeter zero center section of the Hickok Model 209A may be much more conveniently used to make such alignments. Merely connect it across the discriminator load resistance. Make *the necessary* alignment which will bring the meter back to the zero center position. Thus a satisfactory alignment can be made without the necessity of breaking the circuit to insert the microammeter.

5.3 A.C. VOLTMETER

a. Normal

(1) The a.c. voltmeter impedance has a constant resistive component of approximately 15 megohms shunted by a capacitive *component of approximately 6 mmf. The* low shunting capacity is attained by the use of the diode probe, and consequently, measurements of voltages over 100 mc. are possible. The range can further be extended by using a braided connection from the ground post of the diode head to the *chassis of the unit* under test. This lead should be as short as possible to reduce the possibility of an inductive effect being present along the lead. At high frequencies, the shunt capacity, although it is only about 6 mmf, will have a low reactance and may introduce some error in the reading obtained. This error is dependent upon the impedance from which the voltage is measured, and increases as the impedance increases. Also at these frequencies the loading imposed by the capacity input may detune a radio frequency circuit.

(2) The a.c. input circuit includes a blocking condenser between the test prod and the diode circuit, so that any d.c. components present in the circuit under test are ineffective and only the a.c. components are measured.

(3) When the a.c. voltmeter is used to measure voltages of supply line frequency; *for* example, the common 60 cycle supply, small discrepancies in the readings may occur if the polarity of the test leads is reversed; that is, if the grounded test lead changes in position with respect to the a.c. voltage being measured. The actual voltage *in such cases* should be taken as the average of the two readings obtained.

b. Peak-to-Peak

(1) The probe a.c. voltmeter has a constant *impedance of* 15 *megohms shunted* by approximately 6 mmf. Therefore, the loading will be negligible at lower frequencies. Slight detuning of R-F circuits under test

is to be expected.

(2) The peak-to-peak voltmeter is designed primarily for the study of irregular wave forms in television receivers. Practically all television receiver manufacturers in their service manuals give the necessary data pertaining to peak-to-peak volts the study of non-sinusoidal wave forms.

(3) The blocking condenser eliminates the d.c. component, and therefore only the a.c. component will be measured.

(4) To have greater accuracy when measuring peak-to-peak readings between 0 to 12 volts, reference to the Chart, Figure 4.1, may be made.

c. 1200 Volts A.C.

(1) The a.c. voltmeter, 1200 volts a.c., has an input impedance of 3.5 megohms approximately, and is designed for measuring the voltage of power transformers up to 1200 volts. A d.c. path is returned to ground, and therefore it should not be used in a.c. circuits having d.c. components, unless a blocking condenser is inserted between the pin jack and the circuit under test. Be sure the voltage rating of the condenser is equal to, or in excess of, the voltage of the d.c. + a.c. voltage being measured.

5.4 OHMMETER

a. The ohmmeter section of the Model 209A uses only 3 volts, d.c., for all resistance measurements. Many resistors, especially of the composition type, have what is known as a voltage coefficient; that is, the actual value of the resistance varies with the voltage placed across the resistors. This is especially true at resistance values above one megohm. As an example of this, a resistor measured with 3 volts, as in the Model 209A, to be 5 megohms might differ from 5 megohms if it were measured with several hundred volts. This difference would depend on the voltage coefficient of the resistor.

b. On the lower ranges the internal shunt resistance between the test leads used in resistance measurements is relatively low. It is advisable, therefore, never to connect the test leads across a voltage which could possibly damage or destroy these resistors. To avoid this, be sure that the resistor being measured is not connected to an active circuit where measurements are being made.

5.5 CAPACITY MEASUREMENTS

a. In conventional capacitance measuring devices it is necessary to use very high voltages for measuring capacitors of low capacity with a resultant hazard to the operator. This hazard has been completely eliminated in the Model 209A, and capacity test leads may be handled without fear of electrical shock, as the electronic circuit utilized permits capacity measurements throughout the wide range of approximately 1 mmf to 1000 mfd with the use of only 6 volts, a.c.

SECTION 6 - MAINTENANCE

6.1 GENERAL

As the Model 209A has been built under the high standards of workmanship of a Hickok instrument, no maintenance other than routine replacement of tubes or batteries should be necessary. It is suggested that, if the instrument should need maintenance, other than routine replacements, the factory should be contacted with regard to the nature of the trouble, and if necessary, the instrument may be shipped to the factory or to an authorized repair station. A schematic, shown in Figure 7.1, and a chassis view, shown in Figure 6.1, are given to aid in maintenance work.

6.2 VACUUM TUBES

All vacuum tubes are operated at their normal rating, or below, to insure long life and uniform service. To check the tubes, remove the chassis from the case by removing the eight screws around the edge of the panel and lifting the panel from the case.

6.3 DRY CELLS

Two dry cells are operated in series as a source of d.c. in making ohmmeter measurements. If it is impossible to bring the meter to full scale deflection on any scale, it is probable that one or both of the dry cells are low. To replace these, remove the chassis from the case as given in Paragraph 6.2 above, and remove the dry cells. First, it will be necessary to remove the clamp holding the cells in place before removing the cells from their clip holders.

NOTE

IF THE METER POINTER MOVES VIOLENTLY TO THE LEFT WITH THE SELECTOR SWITCH IN OHMS POSITION, REMOVE THE MODEL 209A FROM ITS CASE AND CHECK THE ELECTRICAL CONTACTS OF BATTERIES BT1 AND BT2.

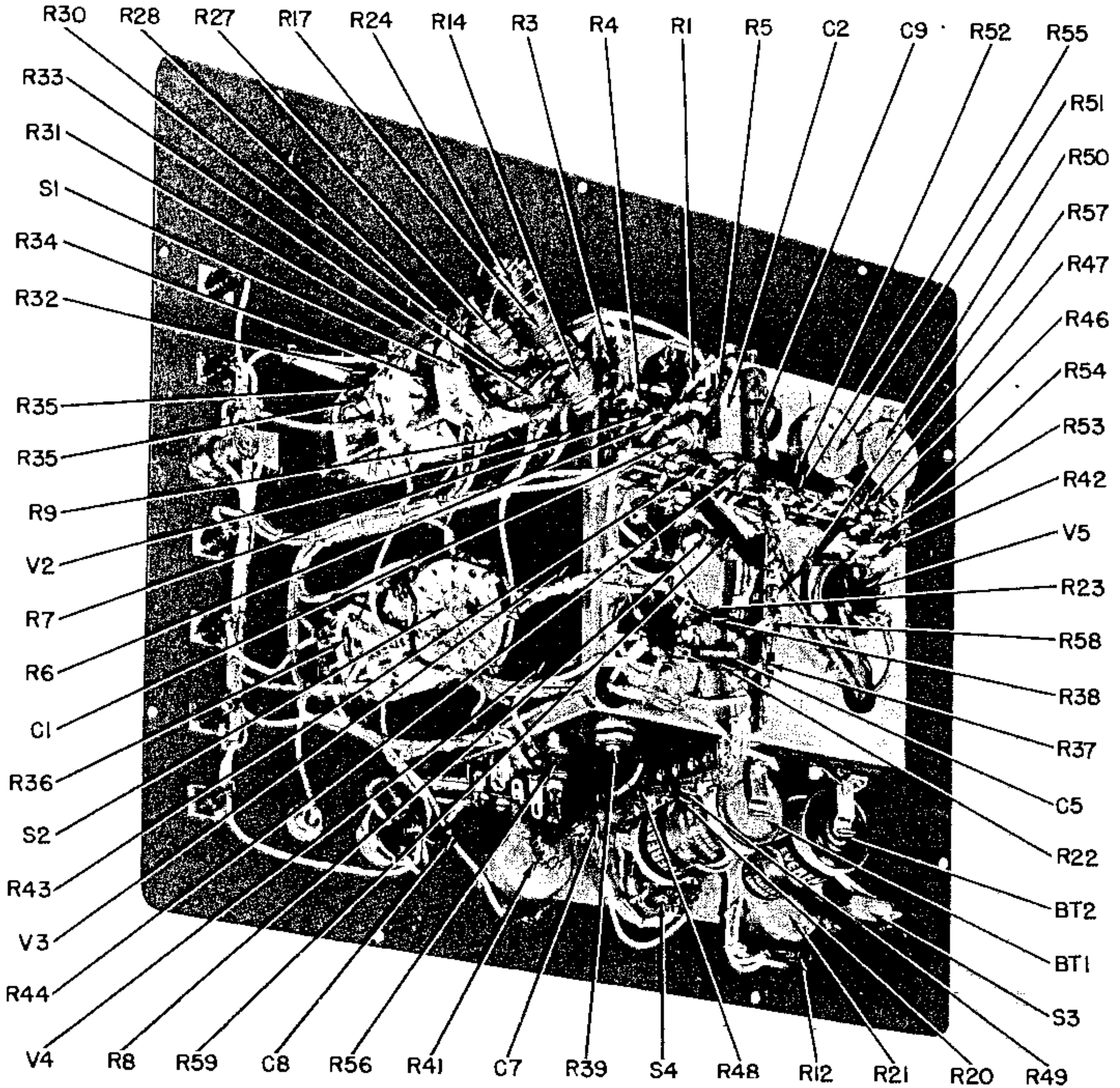


FIG. 6.1 CHASSIS VIEW, MODEL 209A

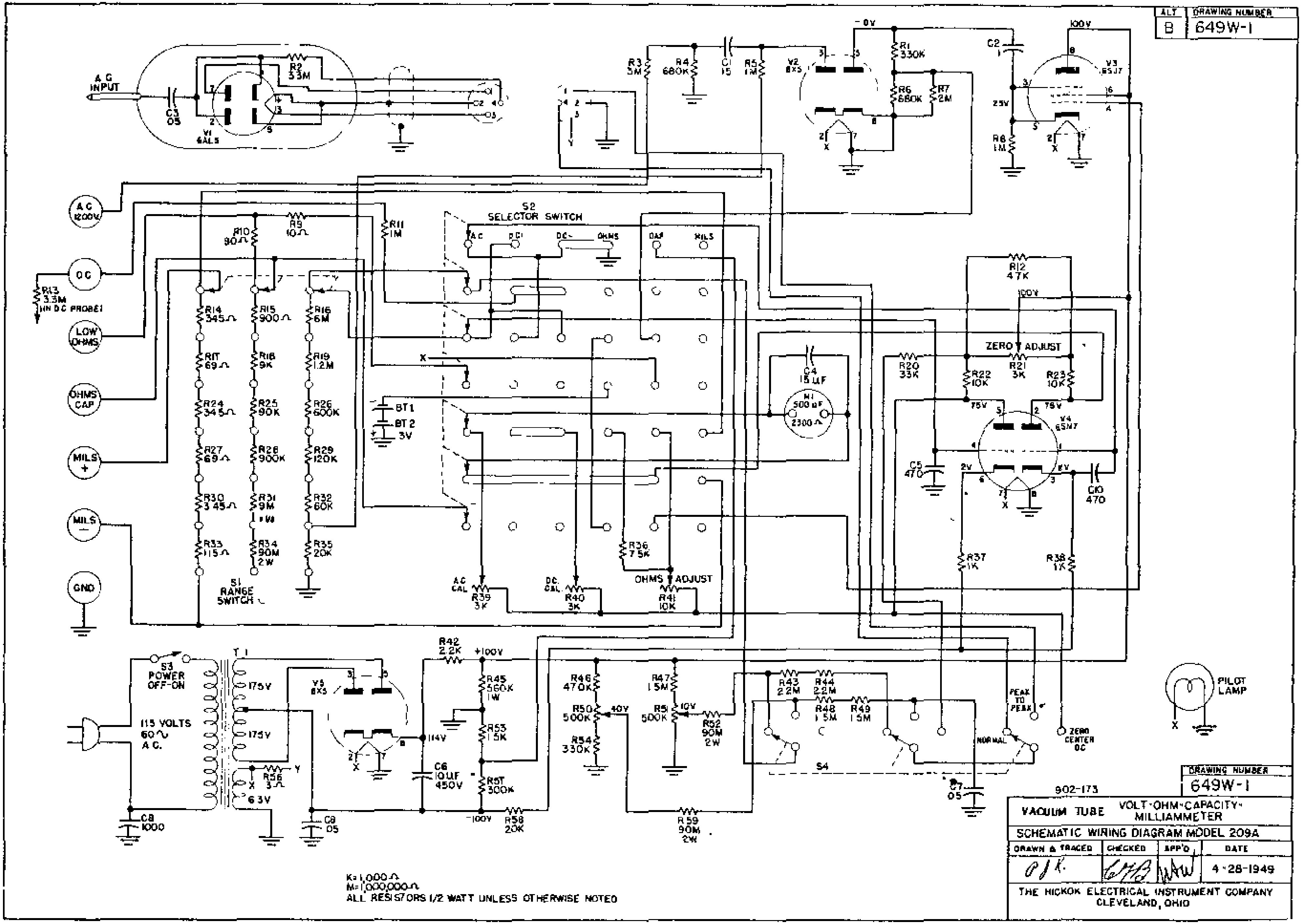


FIGURE 7.1 SCHEMATIC, MODEL 209A